

CLAIMS

1. A business-to-business application service provider with a software tool  
5 environment offered on a pay-per-use basis for system-on-a-chip designers to create  
unique intellectual property, comprising:

an Internet website accessible to at least one system-on-a-chip designer, and  
able to accept uploads of electronic designs in a hardware description language  
(HDL);

10 an EDA-on-demand solution hosted on the Internet website and providing a  
front-end electronic design automation (EDA) tool, and connected to receive said HDL;  
and

15 a subscription controller that provides for a billing of said system-on-a-chip  
designer as a condition of downloading back a simulated and verified derivative of  
said electronic design over the Internet;

wherein, users of said EDA-on-demand solution are charged a pay-per-use fee  
to create a unique intellectual property.

2. ~~The business-to-business application~~ service provider of claim 1, wherein the  
20 EDA-on-demand solution comprises an electronic design automation (EDA) computer  
program for:

generating an electronic circuit design;

partitioning said electronic circuit design into its constituent blocks and protocol  
design;

5-6A 25 coding said constituent blocks and protocol design in hardware description  
language (HDL);

using high-level synthesis (HLS) for operation scheduling and resource  
allocation of said constituent blocks and protocol design;

30 technology-independent Boolean optimizing said constituent blocks after  
operation scheduling and resource allocation to produce an intermediate design;

technology-mapping said intermediate design to select particular devices for a  
hardware implementation of said electronic circuit design;

placing said particular devices at locations in a semiconductor chip; and  
routing a set of interconnections of said particular devices;

wherein, the step of technology-mapping comprises the sub-steps of:

partitioning an original circuit design into a set of corresponding logic  
5 trees;

ordering said set of corresponding logic trees into an ordered linear list  
such that each tree-T that drives another ordered tree precedes said other ordered  
tree, and such that each ordered tree that drives said tree-T precedes said tree-T;

sweeping forward in said ordered linear list while computing a set of  
10 Pareto-optimal load/arrival curves for each of a plurality of net nodes that match a  
technology-library element; and

sweeping backward in said ordered linear list while using said set of  
Pareto-optimal load/arrival curves for each of said net nodes and a capacitive load to  
select a best one of said technology-library elements with a shortest signal arrival time;

15 wherein, only net nodes that correspond to a gate input are considered,  
and any capacitive loads are predetermined.

3. The business-to-business application service provider of claim 1, wherein the  
EDA-on-demand solution comprises an electronic design automation (EDA) computer  
20 program for:

partitioning an original circuit design into a set of corresponding logic trees  
replacing each said logic tree with an equivalent simplified tree having no  
interior nodes;

analyzing each path from a tree leaf to its root in said original circuit;

25 computing a propagation delay for each said path; and

annotating computed delays onto corresponding arcs of said simplified trees.

4. The business-to-business application service provider of claim 3, wherein said  
electronic design automation (EDA) computer program further provides for:

30 annotating any dependency of a propagation delay of said original circuit  
design on a slew rate of an input signal onto a corresponding leaf of said simplified  
tree.

5. The business-to-business application service provider of claim 3, wherein said electronic design automation (EDA) computer program further provides for:

5 copying any capacitive load values from any leaves of said logic tree to corresponding leaves of said simplified tree.

6. The business-to-business application service provider of claim 3, wherein said electronic design automation (EDA) computer program further provides for:

10 copying a load/delay response curve of an output gate at an apex of said logic tree, to a root of said simplified tree.

7. The business-to-business application service provider of claim 3, wherein said electronic design automation (EDA) computer program further provides for:

15 collapsing an entire delay calculation into a simple edge-weighted longest-path traversal within an interior of an abstract timing model of a resource.

8. The business-to-business application service provider of claim 3, wherein said electronic design automation (EDA) computer program further provides for:

20 calculating timing delays for an electronic design with a combination of complex-model trees that interface circuit boundaries and simple-model trees that are internal and do not interface with circuit boundaries.

9. The business-to-business application service provider of claim 3, wherein said electronic design automation (EDA) computer program further provides a technology selection process comprising the steps of:

25 partitioning an original circuit design into a set of corresponding logic trees;  
ordering said set of corresponding logic trees into an ordered linear list such that each tree-T that drives another ordered tree precedes said other ordered tree, and such that each ordered tree that drives said tree-T precedes said tree-T;

30 sweeping forward in said ordered linear list while computing a set of Pareto-optimal load/arrival curves for each of a plurality of net nodes that match a technology-library element; and

sweeping backward in said ordered linear list while using said set of Pareto-optimal load/arrival curves for each of said net nodes and a capacitive load to select a best one of said technology-library elements with a shortest signal arrival time;

wherein, only net nodes that correspond to a gate input are considered, and any capacitive loads are predetermined.

10. The business-to-business application service provider of claim 3, wherein said electronic design automation (EDA) computer program further provides for:

generating an electronic circuit design;

partitioning said electronic circuit design into its constituent blocks and protocol design;

coding said constituent blocks and protocol design in hardware description language (HDL);

using high-level synthesis (HLS) for operation scheduling and resource allocation of said constituent blocks and protocol design;

technology-independent Boolean optimizing said constituent blocks after operation scheduling and resource allocation to produce an intermediate design;

technology-mapping said intermediate design to select particular devices for a hardware implementation of said electronic circuit design;

placing said particular devices at locations in a semiconductor chip; and

routing a set of interconnections of said particular devices;

wherein, the step of technology-mapping comprises the sub-steps of:

partitioning an original circuit design into a set of corresponding logic trees;

ordering said set of corresponding logic trees into an ordered linear list such that each tree-T that drives another ordered tree precedes said other ordered tree, and such that each ordered tree that drives said tree-T precedes said tree-T;

sweeping forward in said ordered linear list while computing a set of Pareto-optimal load/arrival curves for each of a plurality of net nodes that match a technology-library element; and

sweeping backward in said ordered linear list while using said set of Pareto-optimal load/arrival curves for each of said net nodes and a capacitive load to select a best one of said technology-library elements with a shortest signal arrival time;

wherein, only net nodes that correspond to a gate input are considered, and any capacitive loads are predetermined.

11. The business-to-business application service provider of claim 10, wherein:

the step of using high-level synthesis is such that a timing analysis is applied each time an individual operation is scheduled, and may called many times to get a single operation scheduled.

12. The business-to-business application service provider of claim 10, wherein:

the step of technology mapping maps abstract Boolean gates of said electronic circuit design to standard cells from a technology library.

13. The business-to-business application service provider of claim 3, wherein said electronic design automation (EDA) computer program further provides for transforming a hardware-description language text representing a sequential program into a control-flow graph for later operation scheduling and technology allocation by:

reducing a hardware-description language text representing a sequential program into a control-flow graph;

constructing a one-hot-bit finite state machine from said control-flow graph; and

predicting an operational timing of said one-hot-bit finite state machine before operation scheduling in an electronic design automation system;

wherein, a cycle-by-cycle timing congruence is maintained between said hardware-description language text and a final synthesized design.

14. The business-to-business application service provider of claim 13, wherein:

the reducing comprises a step-by-step reduction of a parse tree;

wherein, particular parse tree structures are recognized and corresponding subgraphs are constructed.

15. The business-to-business application service provider of claim 14, wherein:  
the reducing begins with the construction of a simple graph having a reset node  
and a join node with a trivial self-loop;  
wherein an "always" construct is implemented.

16. The business-to-business application service provider of claim 15, wherein:  
the reducing continues by transforming said simple graph into a more elaborate  
control-flow graph by applying a procedure to any parse-tree statements annotated  
onto any arcs;  
wherein an arc that has a statement is removed and replaced with at least two  
new arcs and at least one new node.

17. The business-to-business application service provider of claim 16, wherein:  
the reducing continues by applying said procedure recursively to all said parse-  
tree statements annotated onto all said arcs;  
wherein all decomposable statements are processed.

18. The business-to-business application service provider of claim 17, wherein:  
the reducing continues by saving a name of any labeled block in a table that  
maps such name to a node "end";  
wherein said node "end" provides a destination for any Verilog "disable"  
statements.

19. The business-to-business application service provider of claim 17, wherein:  
the reducing continues by introducing an iteration-counter variable in a case of  
a "repeat" loop;  
wherein said iteration-counter variable is initialized before entering said loop  
and is incremented each time said loop rolls around.

20. The business-to-business application service provider of claim 17, wherein:

the reducing continues by attaching a condition to each of two out-arcs of a new node "iter" for a "repeat" loop, a "while" loop, or a "for" loop.

21. The business-to-business application service provider of claim 17, wherein:  
the reducing continues by removing any arcs and nodes that are unreachable by a forward transversal from a "reset" node.

22. The business-to-business application service provider of claim 17, wherein:  
the reducing continues by collapsing together any sets of arcs resulting from branches containing no further graph structure and re-annotating any conditional parse trees onto said control-flow graph.

23. The business-to-business application service provider of claim 17, wherein:  
the reducing continues by detecting if any conditionals have no effect on said control-flow graph other than a creation of a surplus branch, and if so not applying a reduction and annotating said conditionals as they are.

24. The business-to-business application service provider of claim 17, wherein:  
the reducing continues by removing any dead branches whose conditions can never be true.

25. The business-to-business application service provider of claim 17, wherein:  
the reducing continues by merging the in-arcs and out-arcs of simple nodes with one in-arc and one out-arc that are not marked as states.

26. The business-to-business application service provider of claim 17, further including:

pruning of said control-flow graph after the step of reducing to accommodate a Verilog "disable" statement in said hardware-description language text.

27. The business-to-business application service provider of claim 17, further including:

the pruning of said control-flow graph after the step of reducing to accommodate a "goto" statement in said hardware-description language text.

28. The business-to-business application service provider of claim 13, wherein:

the step of constructing said one-hot-bit finite state machine includes mapping each state node of said control-flow graph to a corresponding single-state flip-flop; wherein, a respective state is indicated when any flip-flop output is true.

29. The business-to-business application service provider of claim 16, wherein:

the step of constructing said one-hot-bit finite state machine continues by constructing a table MAP;

wherein, any arcs of said control-flow graph are mapped to a corresponding output port of said finite state machine.

30. The business-to-business application service provider of claim 29, wherein:

the step of constructing said one-hot-bit finite state machine continues by building a circuit which is driven by a set of primary inputs and state flip-flops, and which drives a MAP(C).

31. The business-to-business application service provider of claim 30, wherein:

the step of constructing said one-hot-bit finite state machine includes using a procedure approximated by,



Procedure cct(c)

T = PAM(c);  
N = { the node at the feather end of C }  
If (N is a state node) {  
    Connect T to the Q pin of FLOP(N).  
} else if (N is a join node with K in-arcs) {  
    G = a new k-input OR gate  
    Connect the output of G to T.  
    for (each in-arc A of N) {  
        Let P = MAP(A).  
        If (P is null) {  
            construct a new output pin named P.  
            set MAP(A) = P.  
            call cct(A).  
        }  
        connect P to an unconnected input pin of G.  
    }  
} else if (N is a fork node) {  
    Construct a new 2-input AND gate G.  
    Connect the output of G to T.  
    Let A be the in-arc of N.  
    Let P = MAP(A).  
    If (P is null) {  
        Construct a new output pin named P.  
        Set map(A) = P  
        Call cct(A).  
    }  
    Connect one input of G to P  
    Make the other input of G a primary status input  
    Corresponding to the branch condition  
    That is annotated onto A.  
} else if (N is the reset node) {  
    Connect P to the reset input.  
} else {  
    Let A be the in-arc of N.  
    Let P = MAP(A).  
    If (P is null) {  
        Construct a new output pin named P.  
        Set map(A) = P  
        Call cct(A).  
    }  
    Connect P to T.  
}  
end